Title: **The impact of rainfall error characterization on the estimation of soil moisture fields in a land data assimilation system,** *Journal of Hydrometeorology* **(American Meteorological Society)**

Author list w/ email addresses:

Viviana Maggioni   Viviana.Maggioni@uconn.edu
Rolf H. Reichle   Rolf.Reichle@nasa.gov
Emmanouil N. Anagnostou   Manos@engr.uconn.edu

Abstract:

   This study presents a numerical experiment to assess the impact of satellite-rainfall error structure on the efficiency of assimilating near-surface soil moisture observations. Specifically, the study contrasts a multi-dimensional satellite rainfall error model (SREM2D) to a simpler rainfall error model (CTRL) currently used to generate rainfall ensembles as part of the ensemble-based Land Data Assimilation System developed at the NASA Global Modeling and Assimilation Office. The study is conducted in the Oklahoma region using rainfall data from a NOAA multi-satellite global rainfall product ("CMORPH") and the National Weather Service rain gauge-calibrated radar rainfall product ("WSR-88D") representing the 'uncertain' and 'reference' model rainfall forcing, respectively. Soil moisture simulations using the Catchment land surface model (CLSM), obtained by forcing the model with 'reference' rainfall, are randomly perturbed to represent satellite retrieval uncertainty, and assimilated into CLSM as synthetic near surface soil moisture observations. The assimilation estimates show improved performance metrics, exhibiting higher anomaly correlation coefficients (e.g. ~0.79 and ~0.90 in the SREM2D non-assimilation and assimilation experiments for root zone soil moisture, respectively) and lower root mean square errors (e.g. ~0.034 m3/m3 and ~0.024 m3/m3 in the SREM2D non-assimilation and assimilation experiments for root zone soil moisture, respectively). The more elaborate rainfall error model in the assimilation system leads to slightly improved assimilation estimates. In particular, the relative enhancement due to SREM2D over CTRL is larger for root zone soil moisture and in wetter rainfall conditions.

Popular Summary:

   When it rains the soil gets wet. How wet it gets depends to a large part on how much it rains. It is difficult, however, to measure precipitation accurately at daily or hourly intervals and at the global scale. And it is even more difficult to measure the corresponding soil moisture, which is important for many applications including weather and climate forecasting, agriculture, drought, floods, landslides, and human health. A standard approach to estimating soil moisture globally is therefore to use numerical models of land surface processes (so-called land surface models) to convert the precipitation estimates into soil moisture estimates, and to combine these estimates with satellite observations of surface soil moisture in a process known as data assimilation. In this process, the estimates from the land model and the satellite observations are merged based on their respective uncertainties. Naturally, uncertainty in the input precipitation

estimates is a major source of error in the modeled soil moisture used in the data assimilation system.

Therefore, it is important to have an appropriate model for the error structure of precipitation estimates from satellite sensors. This study assesses the impact of satellite-rainfall error structure on soil moisture data assimilation by contrasting a complex satellite rainfall error model (SREM2D) to the standard (CTRL) rainfall error model used to generate ensembles of rainfall error fields as part of the Land Data Assimilation System developed at the NASA Global Modeling and Assimilation Office (LDAS). We used high-resolution (25-km / 3-hourly) satellite rainfall fields (to force the land model within the assimilation system) and rain gauge-calibrated radar rainfall fields (considered as the reference rainfall). Soil moisture simulations using the Catchment land surface model (CLSM), obtained by forcing the model with 'reference' rainfall, are randomly perturbed to represent satellite retrieval uncertainty, and assimilated into CLSM as synthetic near surface soil moisture observations. The assimilation system uses either the SREM2D or the CTRL rainfall error model. In both cases, the assimilation estimates show improved performance metrics (relative to model-only estimates), exhibiting lower errors and better agreement in temporal variations versus the reference soil moisture. Using the more elaborate SREM2D rainfall error model in the assimilation system leads to slightly improved assimilation estimates. In particular, the relative enhancement due to SREM2D over CTRL is larger for root zone soil moisture and in wetter rainfall conditions.